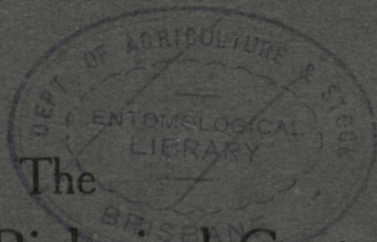


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COMMONWEALTH PRICKLY-PEAR BOARD



The  
Progress of Biological Control  
OF  
Prickly-pear in Australia

BY

ALAN P. DODD

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PUBLISHED UNDER THE AUTHORITY OF  
THE COMMONWEALTH PRICKLY-PEAR BOARD

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Brisbane, October 1929.

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**PLATE I.**

Destruction of *Opuntia inermis* by *Cactoblastis* at Pallamallawa, N.S.W., July 1929.

(J. A. Lunn, photo.)



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ERRATUM :

In title hereunder, for " Queensland " read " Australia. "

# The Progress of Biological Control of Prickly-pear in Queensland

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## I.—INTRODUCTION.

This report discusses the operations of the Commonwealth Prickly-pear Board to the end of May 1929, and reviews the present situation with regard to the control of the prickly-pear pest. Two former publications, "The Natural Enemies of Prickly-pear and their Introduction into Australia" by W. B. Alexander, and "The Biological Control of Prickly-pear in Australia" by A. P. Dodd, published in 1925 and 1927 by the Commonwealth Council for Scientific and Industrial Research, have dealt with the activities of the Board.

### 1.—The Prickly-pear Pest in Australia.

Prickly-pears are members of the Cactaceae, a plant family peculiar to North and South America, where there exist some 350 species of *Opuntia*, the genus in which the prickly-pears are included. For various reasons these plants have been introduced and have flourished in many parts of the world, and certain forms have assumed the dimensions of serious pests in South Africa, India, and Madagascar, although to a lesser extent than in Australia.

The spread of prickly-pear in this country represents the greatest example extant of the invasion of a plant pest or noxious weed. Over twenty species can be found growing in a wild state in Australia, but many of these occur in small quantity in one or more localities. The original establishment of most of these forms cannot be traced, although it is apparent that they were introduced at different periods from widely separated localities in America. The first introduction of prickly-pear can be definitely ascribed to Governor Phillip and the earliest colonists in 1788; the plants were brought from Brazil, and were probably *Opuntia monacantha*. The next record is of a plant conveyed in a flower-pot to Scone, N.S.W., about 1839; apparently this was the main pest pear, *Opuntia inermis*, and from this one plant the tremendous *inermis* infestation has evidently developed. From Scone, plants or cuttings were transported at intervals to the pastoral areas, where they were grown as hedges around the homesteads. Prickly-pear commenced to get beyond control about the year 1870; in 1893 it was reported in New South Wales that many thousands of pounds had already been spent on its eradication, and in 1895 it was added to the list of noxious weeds in Queensland. By the year 1900 it had claimed an area of about 10,000,000 acres, and

following the breaking of the great drought in 1902 it increased so alarmingly that by 1920 its infestation covered 60,000,000 acres, an area greater than that of Great Britain, while its rate of spread was then estimated at about 1,000,000 acres per annum. We may regard the year 1925 as the climax of this remarkable plant invasion; since then the various measures taken to combat the scourge have reduced, if not entirely arrested, the yearly increase.

The prickly-pear area extends in an almost continuous line from Nebo, Queensland, in latitude 22 deg. S., to Maitland, N.S.W., in latitude 33 deg. S., with a great westward extension as far as Charleville, Queensland; isolated areas of considerable dimensions occur around Blackall, Queensland, and in New South Wales at Camden, Gilgandra, and the Pilliga Scrub; the coastal agricultural districts are little affected by the pest, the main infestation embracing the more inland pastoral country, where the land is worth less than £1 per acre. Therein lies the great problem of the control of prickly-pear, as eradication by chemical or mechanical means is not economically practicable except on lightly infested country, or on valuable land where destruction can be accomplished at a relatively low cost.

The common pest pear, *Opuntia inermis*, covers an area much larger than all other species of prickly-pear in Australia; this plant, which is a native of the coastline of the United States from Texas to Florida, has overrun about 50,000,000 acres. The spiny pest pear, *O. stricta*, a native of Florida and the West Indies, has occupied several million acres in Central Queensland. Of lesser importance, the tiger-pear, *O. aurantiaca*, the dreaded jointed cactus of South Africa, whose home is Uruguay, is mainly confined to parts of Southern Queensland; the velvety tree-pear, *O. tomentosa*, a native of Mexico, forms dense forests among the brigalow scrubs of Central Queensland; and the white-spined or Westwood pear, *O. streptacantha*, another Mexican plant, is assuming pest proportions in Central Queensland. The smooth tree-pear, *O. monacantha*, a native of Eastern South America, has a wider distribution than any other form, occurring at intervals from Western Australia to Victoria and North Queensland; in the latter region it formerly covered thousands of acres, but of recent years the Indian cochineal has attacked it so successfully that *monacantha* is now a rare plant.

## 2.—Biological Control and the Formation of the Board.

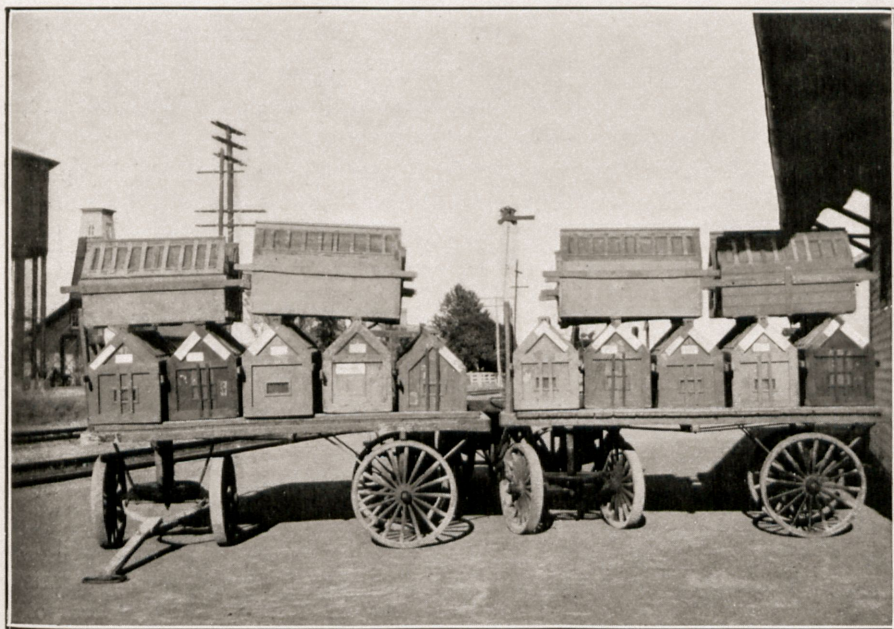
Prickly-pears were brought into Australia without their natural enemies, and remained exempt from injury by native insects. In America, animals, insects, and plant diseases attack the many varieties of pear, feeding on the roots, stems, joints or "leaves," flowers, and fruit, thus checking the growth, destroying the seeds and young plants, and in varied ways assisting to keep the increase of the plants within reasonable limits. Hence, as the pest continued to flourish in Australia, the attention of scientists and others began to concentrate on the advisability of introducing its native enemies; it was reasoned that if these combative

PLATE II.



Breeding Cages and Sheds at the Chinchilla Field Station.

(A. P. Dodd, photo.)



A consignment of Prickly-pear Insects at Uvalde, Texas, ready for despatch to Australia.

(D. C. Parman, photo.)

agencies could be established some measure of control must gradually be exercised. As far back as 1899, Mr. Henry Tryon, formerly Queensland Government Entomologist, advocated this course of action, but no definite steps were taken until 1912, when the Queensland Government appointed a Travelling Commission, comprising Dr. T. Harvey Johnston, now Professor of Zoology at the University of Adelaide, and Mr. Henry Tryon, to investigate the avenues of possible control of prickly-pear. These gentlemen spent eighteen months visiting the many countries where prickly-pears occur, and in their subsequent report recommended the introduction, under safeguards, of certain insects and diseases from America. Moreover, the Commission forwarded to Australia the Indian and Cape cochineals, *Dactylopius indicus* and *D. capensis*, which were released on *O. monacantha* and exterminated the Northern areas of that pest in the course of a few years.

In 1919, the Governments of the Commonwealth, New South Wales, and Queensland agreed to co-operate for a period of five years to carry out a comprehensive investigation of the possibilities of biological control, and the Commonwealth Prickly-pear Board was instituted on 1st June, 1920; subsequently the agreement was renewed for periods of two and three years respectively, and the existing arrangement will terminate on 31st May, 1930. The cost of the investigations has been borne in the proportion of 50 per cent. by the Commonwealth and 25 per cent. by each of the States; the sum of £8,000 per annum was originally allocated for the work, but was increased to £12,000 per annum at the end of 1925, and to £18,000 per annum from 1st July, 1928. The present constitution of the Board is as follows:—

Mr. G. Lightfoot, Secretary of the Commonwealth Council for Scientific and Industrial Research.

Mr. G. D. Ross, Under Secretary, Department of Agriculture, New South Wales.

Mr. F. D. Power, Deputy Chairman, Queensland Prickly-pear Land Commission.

Dr. E. J. Goddard, Professor of Biology, University of Queensland.

The scientific work was under the control of Professor T. Harvey Johnston from the inception of the Board to February 1923; of Mr. J. C. Hamlin from February 1923 to May 1924; of Mr. W. B. Alexander from May 1924 until August 1925; and of Mr. Alan P. Dodd from October 1925 up to the present time.

### 3.—Other Methods of Control.

Although the Board is concerned with control by biological means only, a brief survey of other methods of eradication would not be out of place in this publication.

The earliest attempts at destruction of the pest were made by purely mechanical means, and had a limited application on account of the costly

nature of the work. Poisoning methods by means of injections or sprays, usually with arsenite of soda as the chief ingredient, were less expensive but still too costly. In 1912, the Queensland Government established an experimental station at Dulacca, under the charge of Dr. Jean White (now Dr. Jean White-Haney), who carried out exhaustive poison tests with hundreds of chemical compounds. The work when completed in 1916 definitely proved that arsenic pentoxide was the most efficient specific; this chemical is now the main constituent of all poisons which are quite effective against prickly-pear, but which, owing to the cost of application, are not in general use except for clearing scattered infestations.

#### 4.—Other Government Bodies Concerned in Prickly-pear Control and the Board's Association with them.

In Queensland, a Prickly-pear Land Commission was created in 1924 with wide judicial and administrative powers. This body has carried out a most energetic policy with the aim of stopping the spread of prickly-pear, of establishing buffer areas, of clearing operations in certain localities, and of assisting land-owners in clearing and keeping clean their holdings; through the Commission's vigorous campaign there is less pear, particularly of a scattered nature, in the State at the present time than in 1924, and areas that would have become infested have been maintained free from the pest.

In New South Wales, a Prickly-pear Destruction Commission was formed in 1926, with similar but more restricted functions than those of the Queensland body.

The work of the Commonwealth Prickly-pear Board ceases with the establishment of the various introduced insects, and with the demonstration that these insects can be safely and profitably used to help combat the menace. The distribution of the insects throughout the prickly-pear areas does not fall within the scope of the Board's functions, but is a matter for State action. This work is carried out in Queensland by the Prickly-pear Land Commission, and in New South Wales by the Department of Agriculture, the Prickly-pear Destruction Commission, and the Forestry Department. In this respect, particular mention should be made of the vigorous policy of the Queensland Prickly-pear Land Commission in its campaign of distributing cochineal and *Chelinidea tabulata* by means of special gangs of men with motor lorries throughout the infested areas of the State.

Although the Commonwealth Board does not perform this distributional work directly, close co-operation is maintained with the State authorities. As regards New South Wales, the Board supplies large numbers of *Cactoblastis* eggs to the Department of Agriculture, which body carries out, or arranges to have carried out, the actual distribution. In Queensland, however, the intensive co-ordination with the Prickly-pear Land Commission deserves further reference.

In 1927, the two bodies, viz., the Commonwealth Prickly-pear Board

**PLATE III:**

Dense Prickly-pear, *Opuntia inermis*, in Belah Scrub, unaffected by Insects, Clinchilla, October 1926,

(J. A. Lamm, photo.)



PLATE IV.

Same view as Plate III., showing destruction by *Cactoblastis cactorum*, May 1928,

(J. A. Lunn, photo.)

and the Queensland Prickly-pear Land Commission, formulated a scheme of co-operation whereby the breeding and distribution on a large scale of insects of proven value, more particularly of *Cactoblastis cactorum*, would be accelerated; the funds for the additional activities have been made available by the Commission, and include the upkeep of the Board's field station at Gogango, and the establishment and maintenance of a breeding station at Goondiwindi under the supervision of the Board's officer in charge, who acts also in the capacity of Scientific Advisor to the Commission. Furthermore, the Commission provided the finances for a travelling scholarship in plant pathology from 1925 to the end of 1928, and is at present bearing the greater portion of the expense incurred in the study of plant diseases of prickly-pear in Australia. The Commission, too, recoups the Board for all railway freights incurred in Queensland, and now contributes one-third of the State's quota to the Board's funds.

The close association between the Board and the State authorities has operated very satisfactorily. In discussing the efforts to control prickly-pear by biological agencies, it is not possible to particularise in certain respects between the work of the different bodies. Hence, to give a clear conception of the work performed and the results achieved, this publication must deal not merely with the operations of the Board, but necessarily includes the work of distribution by the aforementioned State authorities.

## II.—THE BOARD'S INVESTIGATIONS.

On its creation in 1920, the Board commenced its investigations by appointing biologists to study the natural enemies of prickly-pear in North and South America, and this phase of the work has been continued without interruption. In Australia, a central receiving and quarantine station was established at Sherwood, near Brisbane, in October 1921; breeding and acclimatising stations were opened at Westwood, near Rockhampton, Queensland, in February 1922 (removed to Gogango in the same district in August 1927); at Biniguy, on the Moree-Inverell Railway, N.S.W., in March 1923 (removed to Gravesend in the same district in November 1924); and at Chinchilla, on the main Western Railway, Queensland, in September 1923. These stations are still in existence and have been enlarged from time to time; in addition, the Queensland Prickly-pear Commission established a breeding station at Goondiwindi, on the N.S.W. border, in November 1927.

The scope of the Board's work includes—

- (a) The search for and study of all prickly-pear insects in their native countries;
- (b) The breeding of material free from parasites and predators;
- (c) The testing of these insects against crops and other plants;
- (d) The forwarding of selected kinds of insects to Australia;
- (e) Their breeding and acclimatising under local conditions;
- (f) Their establishment in numbers at various localities in the field in order to secure bases for supplies for large-scale distribution.

The policy of the Board has aimed at the introduction and acclimatisation of a series or complex of organisms that would attack all the naturalised species of prickly-pear under all conditions of soil, growth, and climate. From the commencement it was faced with great difficulties which had to be overcome gradually. There was no precedent for the control of a gigantic plant invasion by biological means, although on a much smaller scale the same experiment had been carried out with lantana in Hawaii. The breeding of insects in enormous numbers had never been attempted, except in the case of minute parasitic insects that could be housed in a small space. Its scientific staff had to learn patiently the methods for rearing and handling insects on a comprehensive basis. With each kind of insect much preliminary work was necessary in America before introduction into Australia could be even attempted, and then followed the often long process of endeavouring to acclimatise and adapt it to local conditions.

### 1.—Investigations in America.

Members of the Board's scientific staff have in the course of the investigations of insect enemies of prickly-pear visited the following countries in North and South America:—The United States, Mexico, Guatemala, San Salvador, Honduras, the West Indies, Panama, Colombia, Ecuador, Peru, Venezuela, Brazil, Uruguay, and Argentine. Each of these countries possesses a cactus flora, and in each are found insects that live upon prickly-pear, those of each area being, on the whole, distinct; in some regions the variety of prickly-pear insects is limited, while in others, notably the United States and Mexico, there is a wealth of insect enemies of these plants. Some of the surveys have been of a preliminary nature, merely for the purpose of gaining a general knowledge of the possibilities of more extended research, and further investigations are required in several of the countries. Up to the present, there have been discovered about 140 different species of insects which feed apparently only on prickly-pears and other cactus plants. The forms introduced into Australia are natives of the United States, Mexico, and the Argentine.

The United States, offering the largest field for exploitation owing to the occurrence of a greater number and variety of cactus insects, has continued to receive attention since the commencement of the investigations, and the headquarters of the foreign work are established at Uvalde in the State of Texas. From this convenient centre, by rail communication and motor transport, the scientific staff has been able to operate throughout the wide-flung pear areas, from Florida to California, and from the Mexican border northward almost to Canada. The campaign has been conducted thoroughly and intensively, and it can now be claimed that the seventy discovered species of insects represent almost the sum-total of insect enemies of prickly-pears in the United States.

The ancestral home of the Cactus family is generally considered to be Mexico, from where the species have evolved and have spread north to Canada and southward as far as Patagonia; this republic contains a great

abundance and variety of prickly-pears, with many insect enemies. However, owing to unsettled political conditions, the Board's officers have not been able to carry out the necessary thorough investigation, which has been performed intermittently, as circumstances permitted.

The work in the United States may be classed under the following headings:—

- (i.) The study of life-histories;
- (ii.) Testing against economic plants;
- (iii.) Eliminating parasites;
- (iv.) Forwarding to Australia.

(i.) THE STUDY OF LIFE HISTORIES.

This work embraces the searching for the different kinds of insects, and the study of their habits in the field. Insects from various localities are brought to the Uvalde station, where their life histories are investigated under cage conditions. In this phase of the work many kinds of insects are discarded for various reasons that would militate against the likelihood of their being of potential value in Australia. Thus, experiments have shown that insects that attack other types of cactus plants will not thrive on prickly-pears; for example, various kinds of moth-borers of the genera *Cactobrosis*, *Melitara*, &c., that feed within *Cylindropuntia*, *Echinocereus*, and *Echinocactus*, are unable to develop in prickly-pears. Again, a species of prickly-pear insect may increase so slowly and cause so little damage that its introduction into Australia would not be warranted. The more promising forms receive greater attention, and every effort is made to find localities where they occur in sufficient abundance to ensure supplies for shipment to Australia.

(ii.) THE TESTING OF PRICKLY-PEAR INSECTS AGAINST ECONOMIC PLANTS.

It is a fundamental policy of the Board that every possible safeguard should be taken to ensure that the insects introduced into Australia will not turn their attention to crops, fruit trees, and other economic plants. In the first place, insects are selected for investigation only when there is evidence that they are restricted in their feeding habits to prickly-pears and that they do not live on other plants; the study of insects harmful to garden and field crops, fruit and timber trees, in the United States, has reached a stage where it is possible to aver whether a certain insect is a pest or not in that country, and it is fairly certain that had any prickly-pear insect attacked economic plants the knowledge would have been placed on record.

Secondly, a rigorous series of tests with other plants is conducted. At Uvalde the Board maintains an experimental garden of vegetable, cereal, and fruit crops; the insects at various stages in their life-histories are placed on a large number and wide variety of plants; as they are not supplied with prickly-pear, they must either attack the crop plant or die. Should the tests indicate the possibility of any insect being

## PLATE V.



A plant of *O. inermis* on which 60 "egg-sticks" of *Cactoblastis* have been laid, Chinchilla, March 1927.

(J. A. Lunn, photo.)



Same plant in May 1928, showing total destruction.

(J. A. Lunn, photo.)

able to feed and complete its life-cycle on any plant other than prickly-pear, it is excluded immediately from further consideration and no attempt is, of course, made to introduce it into Australia. On the other hand, should the tests be satisfactory and introduction be proceeded with, further tests are carried out at the Board's quarantine laboratory at Sherwood with local plants of importance. The testing work to be performed satisfactorily requires a great expenditure of time and labour; thus, one whole season may be devoted largely to the testing of even one kind of insect, or the testing work with one insect may be spread over two or three years, if sufficient numbers of the particular species are not available to enable the work to be completed expeditiously.

Permission to introduce insects is obtained from the Commonwealth Department of Health and Quarantine, which is fully informed of the relationships, life-history, and habits of each species of insect, and of the results of the tests carried out in America. The Government Entomologists of Queensland and New South Wales are supplied with the same information, and their advice is sought in regard to the completeness of the tests with economic plants. Finally, no species of insect is liberated in the field until the approval of the aforesaid Government Entomologists, and the sanction of the Commonwealth, Queensland, and New South Wales Governments, have been given.

No attempt has been made to acclimatise several species of insects in Australia because the tests indicated that they might attack other plants, and in this connection two instances are given to show the extreme care with which the Board carries out its policy.

There is in America a genus of moth caterpillars that feed in the prickly-pear fruit; one species, *Ozamia clarefacta*, occurs in Texas and frequently destroys whole fields of prickly-pear fruit. As the spread of the pest in Australia can be largely attributed to the enormous quantity of fruits and seeds produced, and disseminated by birds and animals, the importation of a fruit enemy was considered of great importance. *Ozamia* promised to meet this requirement, but the tests showed that it might attack other fruit, and it was therefore discarded from the investigations.

The Board's investigators have reported that the most effective enemy of prickly-pear in Mexico is a large weevil beetle, *Cactophagus spinolæ*, whose grubs bore through the stems and destroy the plants; the importance of this beetle was stressed, and it was pointed out that, in certain areas where varieties of prickly-pear were cultivated for their edible fruit, the inhabitants waged a ceaseless war against these beetles with so little success that replanting had to be carried out every three or four years. When this weevil was reared in cages, the prickly-pear joints were rapidly reduced to a mass of rotten pulp, and, as the beetles could be bred without difficulty, their probable value in Australia appeared second only to that of *Cactoblastis*. But the tests did not prove that *Cactophagus* might not attack other plants, and it too was placed in the category of undesirable introductions.

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(iii.) BREEDING FREE FROM PARASITES AND PREDATORS.

All insects are attacked by parasites and predators that ordinarily keep them within reasonable limits and prevent them from increasing unduly; and each insect has, on the whole, its own particular "set" of natural enemies. The same law of nature applies to plants. As already stated, prickly-pear has spread and increased so rapidly in Australia because its natural enemies were not introduced with the original plants.

The insects released in this country to check prickly-pear must be free from their parasites. To ensure this result they are reared at the Uvalde station and their enemies gradually eliminated so that clean stocks only are forwarded to Australia; or, again, this careful breeding is carried out in quarantine insectaries after their arrival at Sherwood. For example, in America cochineal is so effectively controlled by lady-bird beetles and grubs, and larvæ of Syrphid flies, lacewings, and small moths, that it is rarely abundant. Caterpillars of *Cactoblastis*, *Melitara*, and other moths are parasitised by Ichneumon wasps and Tachinid flies; the *Chelinidea* bugs are attacked by a Tachinid fly; eggs of the *Moneilema* beetles are destroyed by a tiny Chalcid wasp.

The efforts to control and eradicate prickly-pear would be completely nullified if the American parasites were to become established in Australia. The size of the prickly-pear problem and the rapid rate of spread demand that the controlling insects, to be effective, must increase faster than the plant; this is a fundamental principle. Hence the elimination of the natural enemies of the insects is a condition precedent to the successful control and eradication of the pear in Australia.

(iv.) SHIPPING INSECTS TO AUSTRALIA.

Shipments of insects from America are made in specially constructed cases, which are packed with sufficient prickly-pear to provide a food supply throughout the journey. The material is forwarded by mail train from Uvalde to San Francisco, on the boat-deck of steamers from that port to Sydney, thence to Brisbane by rail.

Since the commencement of the investigation, 45 separate shipments, comprising 566 cases, and many thousands of insects of various kinds, have been made.

The Board acknowledges with gratitude the action of the Oceanic Shipping Company of San Francisco (now merged in the Matson line), which conveyed all shipments free of freight up to the end of 1925, and has since charged reduced rates; in most instances, no member of the Board's staff has accompanied the shipments, whose safety and protection receive attention from the ships' officers.

The Board's thanks, too, are due to the New South Wales Department of Railways for its action in conveying the many consignments of insects free of charge from Sydney to Wallangarra, from 1921 up to the present time; to the Railway Commissioners of New South Wales and Queensland, for the expeditiousness and care exercised in transporting

the cases of insects; and to Mr. E. D. Butler, Chief of the Export and Import Branch of the New South Wales Department of Agriculture, who has attended to the receiving of the consignments at Sydney and to their despatch by rail to Brisbane.

Certain problems arise in the shipping of insects; for instance, it has been learnt that each kind must be forwarded at a particular stage of its life-history, otherwise no success is achieved. Secondly, experience has proved that the time of the year is an important factor; in general, insects must be forwarded at the end of the North American summer so as to reach Australia in the spring or early summer; it has been found that those that reach Brisbane before or during the winter usually fail to become established. However, there are exceptions to this rule, and one particular insect must be received at the beginning of our winter in order to give any chance of establishment.

## 2.—Work in Australia.

The Sherwood laboratory acts as the receiving station, where the insects are bred through one or more generations in quarantine insectaries as an additional precaution against the introduction of their parasites or of accidental insects. Here, too, are conducted supplementary tests against crops and other plants.

When the stocks of an insect have increased sufficiently at Sherwood, supplies are forwarded to the field stations at Gogango, Chinchilla, and Gravesend, which act as the acclimatising and breeding centres. The accommodation for insect material has been increased from time to time, and now consists of several hundred breeding cages of various types, with large iron-roofed sheds for protection purposes, at each station.

### (i.) ACCLIMATISATION.

One of the greatest difficulties that the Board has had to face has been the acclimatising of the imported insects. Through countless generations the insects have adapted their life-history to a fixed rotation of seasons. Brought from North America into Australia, they meet with opposite seasonal conditions. Some forms, notably *Cactoblastis*, have been established without great difficulty. Others have been introduced for several successive years, and have steadfastly failed to adapt themselves to Australian conditions; patient experimental work in these instances has resulted in the numbers dwindling and dying out after one or two generations.

The seed-destroying midge, *Asphondylia*, has a life-history particularly regulated by the flowering and fruiting of prickly-pear; the adults emerge in the early spring, March in the United States, and deposit their eggs in the young buds; there is but one generation a year. In Australia, prickly-pear flowers in September and October. Although imported yearly from 1921 onward, it was not until 1927 that the midges were induced to emerge and lay eggs in the buds of our prickly-pears. The problem was solved by forwarding material from the United States in

## PLATE VI.



A healthy plant of *Opuntia stricta*, showing the enormous production of fruit. (H. W. Mobsby, photo.)

April, the fruit infested with the larvæ being kept at Sherwood through the winter; in this manner the life-cycle was reduced from the normal twelve months to six or seven months. If the insects were despatched later than April, they emerged after the flowering period of our prickly-pears had been completed. *Asphondylia* is now being tested against fruits of economic importance.

In attempting to breed insects in large numbers in confinement, the Board has had to devise its own methods. Constant supervision is necessary; the most suitable type of cage must be found for each kind of insect. Conditions must be maintained that will allow a normal functioning and multiplication. During wet weather, disease epidemics are liable to break out and decimate the stocks to such an extent that the patient rearing efforts of two or three years may be destroyed in a few days.

Although an insect has adapted its life-cycle to Australian conditions, and produced generation after generation, yet it may not progress and increase, for reasons some of which are still not understood. Thus the plant-sucking bug, *Chelinidea tabulata*, has multiplied to enormous numbers; yet *Chelinidea canyona*, a very closely related species from the same part of Texas, has been established at Sherwood for several years in small numbers that have shown no indication of permanent increase, at least until the last twelve months; and the true cochineal of commerce, *Dactylopius coccus*, although established on the tree-pear, *O. tomentosa*, in cages at Sherwood since 1924, has made no progress.

Again, in the Board's experience there is one example of an insect flourishing for a time after establishment, and then dwindling in numbers and finally dying out. The moth-borer, *Melitara prodenialis*, was introduced from Florida during 1921-23; the first successful Australian generation was raised in the early summer of 1923. Although the caterpillars showed no partiality for the common pest pear, *O. inermis*, they thrived on *O. stricta* at the Westwood field station, and at the conclusion of the seventh generation, in May 1926, their numbers had been increased from 340 to 155,000. In the succeeding generation the numbers dropped to 23,000, 24,000, and 9,000, after which the species died out, despite every care, in the eleventh generation. Moreover, two liberations, each of approximately 100,000 insects, conducted in February-May 1926, do not appear to have become established.

#### (ii.) ESTABLISHMENT IN THE FIELD.

As stated previously, the purely scientific part of insect establishment ends where it can be proved that a species will adapt itself to Australian conditions and increase sufficiently to be utilised in the control of prickly-pear. Thereafter, the distribution of the proven insects throughout the pear areas is a matter for State action with such assistance as the Board and its technical staff can give.

When an insect has been (1) tested against economic plants, (2)

acclimatised, and (3) bred in cages in large numbers, field experiments are carried out at various localities with the object of determining—

- (a) Whether the insect will breed and increase under natural conditions;
- (b) In which localities the insect will thrive;
- (c) Which kinds of prickly-pear it will attack;
- (d) What destruction is effected to the plants;
- (e) What methods of distribution can be employed.

Moreover, these experimental liberations, whose progress is carefully studied, may become bases of supplies for future large-scale distribution, as in the case of the Board's original liberations of Texas and Arizona cochineal, *Chelinidea tabulata* and *Cactoblastis cactorum*.

The control and eradication of prickly-pear by biological methods depends on the rate of increase, and incidentally of spread, of the released insects or organisms. In the category of insects that have met this requirement are the various strains of the wild cochineal, *Dactylopius tomentosus*, the prickly-pear red spider, *Tetranychus opuntiae*, the plant-sucking bug, *Chelinidea tabulata*, and the moth-borer, *Cactoblastis cactorum*; the rapid multiplication of these forms has fulfilled the most sanguine expectations.

One of the Board's importations, the large moth-borer, *Olyca (Melitara) junctolineella*, has been firmly established in three localities in Queensland and New South Wales since 1924; but although the caterpillars can be located in small numbers several miles from the original liberation sites, no very decided increase has taken place.

*Chelinidea vittiger*, another plant-sucking bug, was released in many localities in both States between 1924 and 1927; at the present time small numbers are existing in several places, but there has been no apparent increase.

Of other importations by the Board may be mentioned the cochineal, *Dactylopius newsteadi*, which is successfully combating the scattered infestations of *Opuntia imbricata*; another cochineal, a strain of *Dactylopius tomentosus* that attacks the hitherto immune *Opuntia streptacantha*, was introduced from Mexico in 1927, and has recently been established in Central Queensland.

### 3.—Research Work with the Introduced Insects.

With the establishment of prickly-pear insects, there gradually arose the necessity for the investigation of their adaptation to Australian conditions, and of their immunity from natural enemies. This work required special concentration. Hence, the Board in the past year has appointed two research entomologists to study various phases of the investigation, of which the most important are—

- (i.) The effect of climatic conditions on the introduced insects;
- (ii.) The Australian parasites of *Cactoblastis*, *Chelinidea*, and cochineal, their life-histories and controlling effect.

## (i.) THE EFFECT OF CLIMATIC CONDITIONS.

Climate is the most important factor in determining the relative increase of any insect. With respect to the introduced enemies of prickly-pear, it has been found that cochineal progresses best during warm, moderately dry weather; heavy rains are extremely detrimental to its increase, while it is probable that a continued drought may not be beneficial. The prickly-pear red spider, also, is adversely affected by rain; as with cochineal, these small soft-bodied insects find insufficient protection on the smooth surface of the pear-pads and are washed off and drowned. *Chelinidea tabulata* seems to be less influenced by weather vagaries than most insects, and no evidence has been obtained that would point to diminution in its numbers either through wet or dry conditions. When acclimatisation was being accomplished in rearing cages in 1921-24, disease epidemics produced serious mortality among the stocks of *Chelinidea canyona* and *C. vittiger*, but *C. tabulata* proved comparatively immune to such causes.

Climatic changes are very important to the welfare of moth caterpillars in general. During periods of excessive rain, diseases have wrought havoc with the stocks of several prickly-pear caterpillars, the species of *Melitara* being very susceptible under cage conditions. *Cactoblastis*, however, has shown greater hardihood than its allies, as the caterpillars are more active in escaping from the wet rotting of the attacked joints, and in the field no serious disease epidemics have yet been observed. But if wet weather is not a serious factor with *Cactoblastis*, on the other hand extreme heat combined with lack of humidity is definitely injurious. It has been discovered that during heat waves, particularly in the months September-November before the summer rains have commenced, the cocoons may be killed in large numbers, the moths may live for a few hours only and die before depositing their eggs, or the eggs themselves may suffer desiccation. Thus, hot dry conditions have, up to the present, prevented *Cactoblastis* from yielding a normal increase in the Blackall district.

Again, for every insect there are areas the climate of which provides the most suitable conditions for multiplication; conversely, in other areas the insects would not thrive. The success of the insects established in Australia can be attributed to the suitability of the climatic conditions; on the other hand, the failure of the Board to acclimatise other forms is probably due to the climate being quite different from that of their native homes. When the introduced prickly-pear insects have been established for a greater period of years, it may happen that they will increase more rapidly and produce greater destruction in some districts than in others. Already, evidence points to this conclusion; for example, although cochineal, *Chelinidea tabulata*, and *Cactoblastis* were liberated at approximately the same time in most of the infested areas, their increase and injurious action have been much less pronounced in the more southern pear regions of the Hunter Valley and around Camden in New South

Wales; perhaps they require a longer period to become thoroughly acclimatised, and ultimately they may multiply as rapidly as in the greater portion of the pear belt.

(ii.) PARASITES AND OTHER ENEMIES.

All insects have their natural enemies, including particular parasites and predators, that destroy the surplus numbers and prevent too rapid increase. The Board has endeavoured to breed the various prickly-pear insects free from these controlling influences, and has been successful in establishing them without their natural checks. Had the American parasites been set free or allowed to escape in Australia, the progress of *Cactoblastis*, *Chelinidea*, and cochineal would not have materialised, and the value of these insects in the control of prickly-pear would have been reduced to minor proportions.

Nevertheless, certain Australian parasites and predators have turned their attention from native hosts to cochineal and *Cactoblastis*. These enemies are being carefully studied by the Board's research officers, and their effect is being watched closely. The ultimate consequences cannot be foretold. There are many instances of introduced insects multiplying to enormous numbers; most of these insects have suffered attack by local enemies, but apparently no case has been recorded where these local parasites have played any considerable part in checking their new host.

(a.) *The Cryptolæmus Ladybird and Cochineal.*

Almost immediately after its introduction into Australia, cochineal was attacked by the native ladybird beetle, *Cryptolæmus montrouzieri*, which is an enemy of mealy-bugs in general. This little beetle and its woolly-covered grubs are present wherever cochineal occurs, and have been the subject for much speculation. Although *Cryptolæmus* has been attacking cochineal since 1922, the degree of control has not appeared great, except in isolated cases.

(b.) *The Local Enemies of Cactoblastis.*

*Cactoblastis* is preyed upon by four native parasites, but, of these, only one is of importance, viz., the Chalcid wasp *Stomatoceras melitaræ*. This little black-and-red wasp, less than a quarter of an inch long, breeds in the cocoons, and has made its appearance in most districts. The proportion of destroyed cocoons is generally small, rarely reaching 5 per cent. except in Central Queensland, where the degree of parasitism has been as high as 12 per cent. in some instances. Thus, so far, *Stomatoceras* is exercising little control on *Cactoblastis*, and its action in the future will be kept under close observation.

Of other enemies may be mentioned ants and birds, which take toll of all insect life. Among the former the most important is the red mound or meat ant, *Iridomyrmex detectus*, which frequents the red clay or gravel soils but is not common in the brigalow and belar scrubs and in the



**PLATE VII.**

*Opuntia stricta* collapsing under Cochineal attack, Westwood, Queensland, October 1926; compare with Plate VI.

(H. W. Mobsby, photo.)



## PLATE VIII.

Almost complete destruction of *Opuntia stricta* in a Brigalow Scrub by Cochineal, Westwood, Queensland, October 1926. (H. W. Mobsby, photo.)

grassy country; it readily devours the caterpillars when they come out of the joints either to seek fresh quarters or to spin their cocoons, but the measure of control is small.

Various reports have been received of the ravages of crows and other birds on *Cactoblastis* caterpillars, but they have not been substantiated by investigation. Indeed, with the vast numbers of caterpillars congregated in a limited area, it is a striking fact that they are practically immune to bird attack. One definite record of depredations by birds has been made; in a Central Queensland locality, scrub turkeys or megapodes were tearing open the pear-joints to eat the larvæ; these birds occur only in the brigalow and vine scrubs and are not particularly abundant.

#### 4.—The Diseases of Prickly-pear.

In the first three years of the Board's existence, some attention was paid to the fungous and bacterial diseases of prickly-pear, but, owing to the larger scope offered by insect enemies of these plants, the disease work was left in abeyance.

However, in 1925 the Board appointed Mr. H. K. Lewcock as a travelling research scholar, with funds provided by the Queensland Prickly-pear Land Commission. After spending eighteen months in Universities in the United States in a special study of plant diseases and of the methods employed in their investigation, Mr. Lewcock undertook a survey of the prickly-pear areas of the United States and visited the Bermuda Islands. Various diseases were studied, of which the most important were a bacterial soft-rot and two anthracnose fungi, *Phyllosticta concava* and *Glæosporium lunatum*.

In August 1928, the Board decided to study the question of the diseases of prickly-pear already established in Australia, and Mr. Lewcock was recalled in February 1929 to take charge of the work. Although the investigation has not passed the preliminary stages, it has been learned that many American prickly-pear diseases are widespread in Australia, including a bacterial soft-rot and the fungi *Glæosporium lunatum* and *Phyllosticta concava*. The bacterial rot is active in association with *Cactoblastis* attack, while *Glæosporium lunatum* may be associated with cochineal infestation. The Board intends to continue this investigation with the object of ascertaining whether further use can be made of any of these diseases, more particularly if their distribution should prove to be limited at present to certain districts.

#### 5.—The Present Status of the Established Insects.

The distribution by the Board and the State bodies of certain insects has progressed to such an extent that very large areas of prickly-pear are now being attacked by these organisms.

The cochineal, *Dactylopius tomentosus*, has been broadcast generally, and it would now be difficult to find an area of prickly-pear in Queensland or New South Wales which is not infested with this insect.

*Chelinidea tabulata* flourishes in countless millions in many localities, and is rapidly spreading both through its own methods of dispersal and through the distributing channels of the State authorities.

The infestation of the prickly-pear red spider, *Tetranychus opuntiae*, covers many thousands of square miles, and should soon extend throughout the length and breadth of the pear area.

The distribution of *Cactoblastis cactorum*, although of recent date, has assumed considerable proportions, about 300,000,000 having been liberated since the beginning of 1926; at the present rate of increase, and with the existing avenues of distribution, this insect should, within two to three years, be prevalent wherever prickly-pear occurs.

It can be stated definitely that the established complex of insect enemies is already bringing about a considerable measure of control of this plant pest. Over large areas the density of the infestation has been reduced very materially. This reduction is most noticeable in the brigalow and belar scrubs, where the pear formed a barrier 4 to 5 feet high, impenetrable even to animals. At the present time the height of the pear has been brought down to an average of 2 feet in large areas of this type of country. In the heart of the pear country it is now possible to travel for 100 miles without seeing any healthy virile plants. The production of fruit and new growth has been greatly diminished, fewer seedlings are able to become established, while the large clumps and plants are being sapped of their vitality and gradually destroyed by the action of the insects. This beneficial result represents the efforts of cochineal, red spider, and *Chelinidea tabulata*, a harmonious combination that is working together over a wide expanse of territory.

*Cactoblastis* deserves special mention owing to the different nature of its action; instead of a slow but insidious destruction, large plants may be eradicated in a very short time. For example near Dulacca, Queensland, in dense pear in a belar scrub, the area of destruction increased from 50 to 1,000 acres in four months (October 1928 to January 1929), and in a similar period, at Wallumbilla, Queensland, the devastation increased tenfold, from 400 to 4,000 acres of *Opuntia inermis*. It is estimated that at least 30,000 acres of prickly-pear have been destroyed by this insect, chiefly in the past twelve months.

#### 6.—Future Prospects.

There is no doubt that the introduction of *Cactoblastis* has completely changed the outlook for prickly-pear eradication. The Board and its scientific officers, although satisfied with the success of the other established insects, were of the opinion that the control and eradication of the pest would prove a slow undertaking. However, the advent of *Cactoblastis*, and the demonstration of its remarkable destructive powers, have given rise to greater optimism.

It would be dangerous because of present indications to attempt to prognosticate the end of the prickly-pear menace. The effect of the



PLATE IX.

A dense forest of *Opuntia tomentosa*, Gogango, Queensland; note dead plants in foreground, a result of Cochineal attack; the white spots on the trunks of the plants are Cochineal colonies.

(H. W. Mobsby, photo.)

insects is too recent to permit indulgence in prophecies, however pleasing the prospect. Nevertheless, with the wider distribution of the insect agencies, more particularly *Cactoblastis*, and with their ever-increasing numbers, the prospects of eventual success are most hopeful. Yearly the density of the pear infestation and the area under its occupation should diminish, and the land be reclaimed for pastoral and agricultural purposes. Indeed, on present promise it is reasonable to expect that vast areas of the pear will be eradicated within a few years.

Here the Board desires to sound a note of warning. The success of a given project rests upon proven results; practical science does not indulge in visions and must take into account all possibilities, favourable and unfavourable. Factors or circumstances may at any time check the destructive rate of the insects' progress. Native parasites, unfavourable weather conditions over a prolonged period, or disease epidemics, may reduce their efficiency. Conceivably, the pear may acquire a greater measure of resistance to its foes, or the insects themselves may lose their virility.

The prickly-pear problem is not yet solved; that propitious stage will not be reached until the pest has actually been eradicated.

### III.—THE PRICKLY-PEAR INSECTS ESTABLISHED IN AUSTRALIA.

It is not the intention in this publication to discuss the many kinds of insects that attack prickly-pear, but a brief account of the several forms that are widely established in Australia may prove of interest. In addition to the acclimatised insects, the Board has attempted to introduce many other varieties, and this work is still being continued; a list of the insect enemies of prickly-pear is given in an appendix.

#### 1.—*Cactoblastis cactorum*.

This insect belongs to an important group of gregarious or social tunnelling caterpillars, of which a number of species occur in North and South America.

*C. cactorum* is a native of Uruguay and the northern portion of Argentine, including the provinces of Corrientes, Entre Rios, Santiago del Estero, and Tucuman. In 1914 the Queensland Prickly-pear Traveling Commission located the caterpillars in the Botanic Gardens at La Plata, Argentine. It was not found by Dr. Harvey Johnston and Mr. W. B. Alexander in their Argentine investigations in 1920-21, although a closely related species, *C. bucyrus*, was located in Western Argentine.

*C. cactorum* was rediscovered by Mr. A. P. Dodd in late 1924 and early 1925; from caterpillars collected at Concordia, in the province of Entre Rios, the ensuing moths emerged in February and March, and laid eggs, of which 3,000 were forwarded from Buenos Aires in March, reaching the Sherwood Laboratory in May 1925, after a voyage of ten weeks; at Capetown, the South African Department of Agriculture removed a few colonies, so that the original and only introduction into Australia consisted of approximately 2,750 caterpillars.

This consignment proved an immediate success; the caterpillars thrived on *O. inermis* and *O. stricta* through the winter in the Sherwood quarantine insectaries, and in September produced moths that deposited 100,000 eggs. These eggs were accommodated in cages at Sherwood and Chinchilla, and the second generation, in February-March 1926, yielded 2,540,000 eggs, a tremendous increase of over 900-fold in 12 months. At this stage, twenty experimental liberations, comprising 2,250,000 eggs, were made at selected localities; further experimental liberations were conducted during the summer of 1926-27. Thus, the Board liberated 9,000,000 eggs in many places from Emerald, in Central Queensland, on the north-western fringe of the pear area; to Camden, N.S.W., at the southern extremity of the infested country, in the period February 1926 to March 1927.

These liberations progressed so well that early in 1927 rearing the caterpillars in cages became unnecessary; thenceforward, the quantity of material in the open was so great that to secure eggs for further distribution the cocoons were collected from the field, the moths being allowed to emerge and lay their eggs in cages, and the eggs being collected daily and forwarded to various localities. The original liberations have served as centres for supplies, and the Board discontinued its liberation work in March 1927. Since then, the work of distribution has been carried out by the State bodies concerned in prickly-pear control, who have released over 300,000,000 eggs from September 1927 to March 1929, the majority of these eggs having been obtained from the Board's field stations.

*Cactoblastis cactorum* is a plain-looking brown moth with a wing expanse of slightly over an inch. Its eggs are laid in long chains or "sticks," containing as many as 150 eggs but averaging about 75; one female may deposit 200 eggs but the average is about 100; the eggs take from three to six weeks to develop. The caterpillars pass their existence within the pear segments, and rarely come to the outside except for short intervals; in colour they are orange or orange-red, with black cross-stripes; they attain a length of about an inch, living in colonies of from 20 to 100. When full-grown they spin loose, white, silky cocoons under bark or fallen débris or between the destroyed pear-joints; the cocoon stage has a duration of from three to six weeks. The moths live for a few days only.

In the main there are two generations a year. The moths emerge and lay their eggs in September-October and January-February; the summer brood of caterpillars develops in four to eight weeks, but the winter brood spends about six months in the caterpillar stage. In Central Queensland, however, a third generation may occur in each year; hence, in that section all stages of the insect can be found almost throughout the year.

The caterpillars eat out the interior of the pear joints, tunnelling through from joint to joint, or leaving a destroyed pad to seek fresh quarters; in the case of the younger segments, the whole inside is eaten, leaving only the thin papery cuticle; older pads are not destroyed

PLATE X.



The same area showing destruction by Cochineal, November 1926.  
(J. B. Henderson, photo.)



Dense *Opuntia inermis* at Dulacca, Queensland, October 1922.  
(J. B. Henderson, photo.)

entirely, but wet rots, caused by various fungi and bacteria, find suitable conditions for development and hasten and complete the destruction. The caterpillars may penetrate into the underground bulbs and even the roots of the plants, and with the aid of the associated rots the clumps may be entirely killed.

Although the moths are free-flying and have been known to travel at least ten miles before depositing their eggs, the great majority oviposit in the immediate vicinity of their emergence point. Thus, great numbers of eggs may be laid in a limited area, even to the extent of 1,000,000 eggs an acre. With this vast quantity of caterpillars feeding and giving opportunities for rot conditions to develop, the spectacle is afforded of the pear collapsing and dying from a given point outwards, as though it had been visited by some virulent plague. The numbers of *Cactoblastis* now present in Australia must have reached many thousands of millions, and this vast horde has sprung from the original number of 2,750 introduced in May 1925.

Remarkable destructive results are being obtained with *Cactoblastis* at different points from Central Queensland to Northern New South Wales; up to the present, it has not achieved great success in the more southern pear areas of the Pilliga forest, the Hunter River valley, and the Camden district of New South Wales, nor in the isolated pear area around Blackall, Queensland. However, it appears particularly adapted to the greater portion of the infested territory, and especially inimical to the main pest pear, *Opuntia inermis*. As would be expected, the succulent type of *inermis* of the brigalow and belar scrubs is the more readily destroyed, but very effective work has been wrought on the harder, more resistant type of *inermis* of the open forest lands. *Opuntia stricta* of Central Queensland is rapidly eradicated in the scrub lands, but in the open country the rate of destruction is much slower than in the case of *inermis*. With regard to the other pest pears, *Cactoblastis* is partial to the tiger-pear, *O. auranziaca*, which is readily destroyed; although it freely attacks *O. streptacantha*, complete eradication is not accomplished except with young plants; the younger plants of *O. tomentosa* are destroyed, but the moths show an aversion to the larger plants of this tree pear, on which eggs are seldom deposited.

## 2.—*Chelinidea tabulata*.

Of the plant-sucking cactus bugs of the genus *Chelinidea*, three species have been introduced, but one only, *C. tabulata*, has flourished up to the present. This insect is a native of Central America, extending through Mexico into Southern Texas. Eight consignments of insects, totalling about 1,600 individuals, were introduced by the Board from Texas between July 1921 and October 1923; it became established in 1922, and has continued to multiply. The first liberation, of 100 bugs, was made at Dulacca, Queensland, in December 1922; thereafter, 100,000 were released in numbers of from 1,000 to 5,000 individuals at forty localities in Queensland and New South Wales up to the beginning of

1927. Breeding in cages was discontinued in 1926, and owing to the large increase in the field no further experimental liberations were conducted. In the past two years, the Prickly-pear Land Commission has collected and distributed large numbers of *tabulata* throughout Queensland, and in New South Wales the Department of Agriculture has carried out similar action on a smaller scale.

The adult bug is about half an inch long and of a dull brown colour. In America the eggs are deposited along the pear spines, but here, probably owing to the comparative absence of large spines on *inermis*, they may be found on dead grass-stems, on or under bark of growing trees, or on foliage of shrubs and trees. On hatching from the eggs, the young (termed nymphs) are black and green with dark legs, but soon become bright green with yellow legs. There are two generations a year, the bugs reaching the adult stage in the middle of summer and late autumn respectively. The adults remain alive through the winter, hiding among rubbish at the base of the plants during the cold weather and coming out to feed on warm sunny days.

The bugs feed by inserting the proboscis and sucking the juice from the fruit and joints; around each feeding puncture a small circular yellow area forms, and the presence of the insects can be recognised by these characteristic marks. Where they are numerous, the whole plant becomes yellow and sickly, and is unable to produce fruit and new growth; moreover, as succulent parts of the plant are preferred, green fruit and young joints are destroyed; the young regrowth, that occurs where pear clumps have been killed by *Cactoblastis* or by poison, is soon attacked by the bugs.

*Tabulata* has multiplied to enormous numbers in many localities, and in places many hundreds of acres of dense pear are yellow from its work. Although it rarely kills plants, it plays a considerable part by destroying the young growth, seedlings, and fruits, and by reducing the vitality of the plants, which are thus more susceptible to cochineal attack. It will feed on any species of pear, but shows a marked preference for *inermis*, this partiality being very noticeable in areas where *inermis* and *stricta* occur together.

### 3.—The Cochineals.

Cochineal insects are members of the genus *Dactylopius*, and belong to the mealy-bug section of the scale insect family (Coccidæ). Several species are known, and all are restricted to feeding on prickly-pears and other cactus plants.

The small soft-bodied insects are sheltered beneath a white woolly or downy secretion of fine silky threads. The males are very small delicate-winged flies; the females are wingless. The eggs are laid in numbers beneath the body of the female. The young cochineal or "crawler" is possessed of normal legs, but, when a suitable feeding spot has been located, its trunk or proboscis is forced through the cuticle of the joint, and for the rest of its existence it remains stationary; the legs gradually

**PLATE XI.**

Dense *Opuntia inermis* in Brigalow Scrub collapsing from combined attack of Cochineal, Red Spider, and *Cheltonidea*, Biniguy, N.S.W., July 1929; compare appearance with that of unaffected dense pear in Plate III., page 10.

(J. A. Lamm, photo.)

atrophy and the woolly covering is secreted; the trunk serves to attach the insect firmly to the plant, and attempted removal results in its death. The females are prolific; during the summer, a new brood is produced every few weeks. The crawlers are so small that they can be carried great distances by wind; this method of dispersion explains the rapidity of cochineal spread, and the fact that isolated plants, many miles from other pear clumps, are infested with colonies.

A peculiarity of the cochineal group lies in the highly developed degree of preference for different kinds of prickly-pear. Most species of cochineal confine their attack to a certain number of prickly-pear varieties. Thus both the Indian cochineal, *Dactylopius indicus*, and the woolly cochineal, *D. confusus*, which infest the smooth tree-pear, *O. monacantha*, will not exist on the two pest pears, *O. inermis* and *O. stricta*. The wild cochineal, *D. tomentosus*, will attack *O. stricta*, *O. inermis*, *O. tomentosa*, and *O. monacantha*, but will not live on the tiger-pear, *O. aurantiaca*.

Furthermore, there may be biological strains or races, indistinguishable even to the entomologist, of the same species of cochineal, as for example the Texas, Arizona, and Chico strains of *D. tomentosus*; not one of these races will exist on the white-spined pear, *O. streptacantha*, which is readily attacked by a Mexican race of the same insect.

The Indian cochineal, *Dactylopius indicus*, was introduced from Ceylon by the Queensland Travelling Commission in 1913, and was established successfully at Dulacca by Dr. Jean White-Haney. Another strain was imported from Argentine by the Board in 1925 but, like its predecessor, has not been induced to attack any other prickly-pear except *O. monacantha*. Considerable areas of *monacantha* in North Queensland were rapidly eradicated by *indicus*, and the scattered infestation of this prickly-pear from Queensland to Victoria has been controlled so efficiently that at the present time occasional plants only can be found.

Another cochineal, *Dactylopius newsteadi*, was introduced by the Board from the United States in 1924. This insect attacks the devil's-rope cactus, *Opuntia imbricata*, the scattered infestation of which in Southern Queensland and Northern New South Wales has been considerably reduced by its efforts.

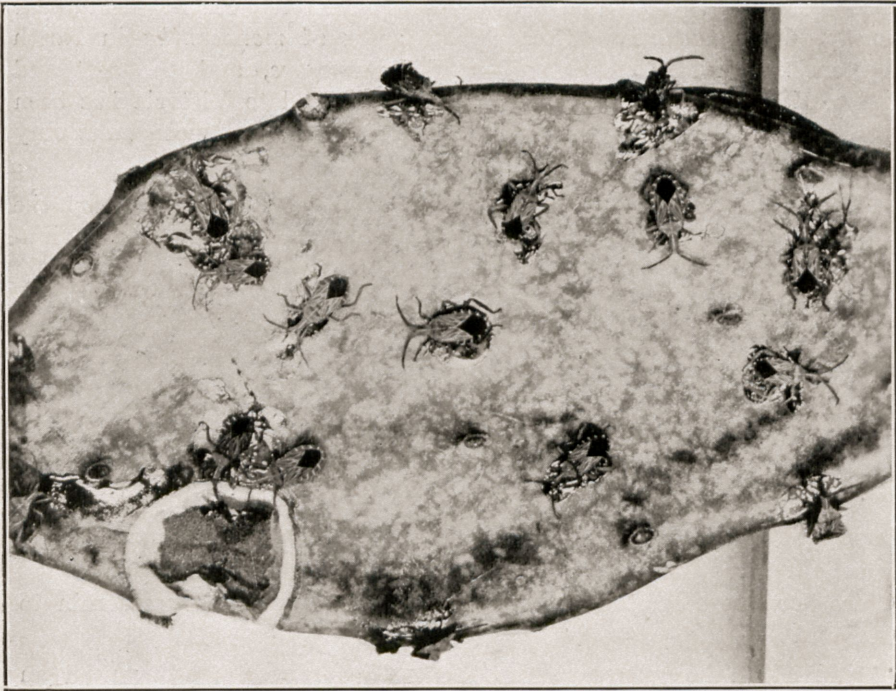
The wild cochineal, *Dactylopius tomentosus*, was first imported from Chico, California, in 1920 by the late Mr. A. Temple Clerk of the Queensland Department of Lands, who established it on *O. inermis* and *O. stricta* at Westwood, Gayndah, and Dulacca (Queensland), and Scone (N.S.W.). The Board introduced and acclimatised this cochineal in 1921-22 from Arizona and Texas. Extensive cage and field experiments proved that, while the three strains would live on both *O. stricta* and *O. inermis*, the Chico form was most destructive to *inermis* and the Texas strain to *O. stricta*.

In 1924, the Queensland Prickly-pear Commission commenced an energetic campaign of cochineal distribution, forwarding supplies to

## PLATE XII.



A heavy infestation of Cochineal, *Dactylopius tomentosus*, on a joint of *Opuntia inermis*. (J. Mann, photo.)



Adults of *Chelinidea tabulata*; the spotted appearance of the Pear is due to the feeding of the bugs. (J. Mann, photo.)

land-owners and utilising motor lorries for infecting prickly-pear growing along roadways; the material was obtained from the original establishments of the Chico, Arizona, and Texas strains; the work was completed in 1927, by which time the insect was thriving wherever the pest occurred. In New South Wales, the distribution of cochineal was carried out by the Department of Agriculture and the Prickly-pear Destruction Board. The three strains must have intermingled freely in the past few years, and, as it is not possible even for an entomologist to distinguish them, no useful purpose would be served by retaining the distinctive names.

The density of cochineal infection depends on weather conditions; the heavy summer rains destroy the crawlers and older colonies; hence its virulence is sporadic, and is greatest in years of low rainfall or during the drier months.

Remarkable destruction was caused by these insects in Central Queensland during 1925-26, years of light rainfall, this being especially true of the Texas strain on *O. stricta*. With a return to more normal seasons the former rate of eradication has not been continued. To illustrate the detrimental effect of heavy rain, may be mentioned the fact that in December 1928, following a several months' dry period, in many localities in Central Queensland prickly-pear was literally white with the density of the cochineal infestation; heavy rains were experienced between December and April 1929, and in the latter month scattered colonies only of the insect had survived the precipitation.

Thus, the earlier destructive results can be considered abnormal. Nevertheless, cochineal is still performing very useful work, particularly in killing the fruit, young growth, and seedlings, and in reducing the height and density of the pear infestation in the brigalow and belar scrubs. At the present time it is yielding more effective results on *O. inermis* than on *O. stricta*, although this was not formerly the case. As this insect prefers shaded conditions, a heavy infection is rarely found on the harder types of prickly-pear growing in the open forest country.

Without the aid of other insects, the effect of cochineal attack would be greatly minimised. Prickly-pear that has been heavily infested with *Chelinidea tabulata* or red spider loses its vitality and at the same time throws out from its lower segments an adventitious growth that differs considerably from the normal seasonal new growth produced from the top joints; these abnormal joints are particularly suited to cochineal, which is able to destroy them with comparative ease. Again, prickly-pear clumps destroyed by *Cactoblastis* or by poisoning produce from the butts and roots regrowth which is quickly attacked by cochineal and has little opportunity of becoming established.

#### 4.—The Prickly-pear Red Spider, *Tetranychus opuntiae*.

This tiny eight-legged mite is a native of Texas, and became established in Australia in 1924. From the several original centres it spread very rapidly, and has now infested a very considerable portion of the

immense pear area. It flourishes on *O. inermis*, has little effect on *O. stricta*, rarely attacks the tree-pear, *O. tomentosa*, and will not exist on *O. streptacantha*.

Like cochineal, red spider thrives during dry periods, and its activities are suspended by heavy rains. But, unlike cochineal, its rate of increase is not affected by cold weather, and it may be very active during the winter months.

The presence of red spider can be recognised at once by the appearance of whitish or greyish circular areas, turning yellow with age, around the spine centres (often termed "eyes") of the pear segments; these patches are composed of a layer of corky matter, apparently caused by the reaction of the plant to the feeding of the mites on the surface of the joints. Frequently the corky areas coalesce and completely cover the segment, which falls off and is destroyed.

Red spider prefers shaded scrub or rather heavy eucalyptus country, and has little effect in open fields. A peculiarity of its mode of attack is that healthy succulent pear alone receives attention; plants devitalised by *Chelinidea* and cochineal invasion escape its infection. The attack may be gradual or sudden; in the latter event, many acres of pear are marked with the white scab areas in a few weeks. Severely affected pear does not seem to recover its vigour; even after a lapse of two years, little new growth of a normal character is produced, and the almost total absence of fruit points to the serious nature of the red spider invasion; if the pear does throw out fresh growth, it usually takes the form of attenuated joints from the lower portion of the plants, which abnormal growth is readily controlled by cochineal and *Chelinidea*. Thus it can be understood that red spider is assisting materially in the control of this plant pest.

## APPENDIX A.

### THE INSECT ENEMIES OF THE CACTACEÆ.

The following list includes all the species of insects which are known, or are considered, to be restricted to feeding and breeding on prickly-pear (*Platyopuntia*) and other plants of the cactus family, and which have been investigated by the Board's officers. It does not include insects that feed on other plants in addition to cactaceæ, nor certain forms recorded by other observers as cactus insects but not encountered during the course of the Board's investigations.

For convenience, the insects are divided into the following groups:—

- (I.) Moth Caterpillars (*Lepidoptera*) that feed internally, or rarely externally, on the stems and joints.
- (II.) Beetle Grubs (*Coleoptera*) that tunnel in the stems and joints.
- (III.) Flower, fruit, and seed enemies, mostly moth caterpillars, with one seed midge (*Diptera*), and one seed Chalcid (*Hymenoptera*).

- (IV.) Plant-sucking Bugs (*Hemiptera*).  
 (V.) Cochineal and other Scale Insects (*Homoptera*).  
 (VI.) Gall-forming Midges (*Diptera*) and Chalcids (*Hymenoptera*).  
 (VII.) Miscellaneous insects not included in the above categories.  
 (VIII.) Scavenging Flies.

The locality of each species is given; unless stated to the contrary, the food-plant is prickly-pear (*Platyopuntia*); where another food-plant, e.g. *Echinocereus*, *Cylindropuntia*, is named, it can be accepted that the insect will not breed in prickly-pears. In regard to the list of scavenging flies, the given species are addicted to breeding in the green joints of prickly-pear in association with other insects; although it is possible that they breed in other decaying vegetable matter, they may be regarded as cactus insects; many other insects live in rotting cactus plants, but they are not primarily cactus insects.

### I.—Moth Caterpillars that Attack the Stems and Joints.

#### PYRALIDÆ: Phycitinæ—

- |  |               |    |   |
|--|---------------|----|---|
| 1. <i>Melitara prodenialis</i> Walker        | U.S.A.        | .. | Introduced from Florida 1921-7, but died out; introduced from Texas 1928-9 and now being reared in cages. |
| 2. <i>Melitara bollii</i> Zeller             | .. Texas      | }  | Introduced 1924-9; acclimatisation still being investigated.  |
| 3. <i>Melitara doddalii</i> Dyar             | .. U.S.A.     |    |   |
| 4. <i>Melitara dentata</i> Grote             | .. U.S.A.     |    |   |
| 5. <i>Melitara parabates</i> Dyar            | .. U.S.A.     | .. | Food-plant <i>Cylindropuntia</i> .  |
| 6. <i>Cactoblastis cactorum</i> Berg.        | Argentina     | .. | Established in Australia.   |
| 7. <i>Cactoblastis bucyrus</i> Dyar          | .. Argentina  | .. | One introduction failed.  |
| 8. <i>Cactoblastis leithella</i> Dyar        | .. Venezuela  | .. | Not introduced.   |
| 9. <i>Olyca junctolineella</i> Hulst.        | .. U.S.A.     | .. | Established in Australia.   |
| 10. <i>Olyca subumbrella</i> Dyar            | .. U.S.A.     | .. | Not introduced.   |
| 11. <i>Olyca nephelopasa</i> Dyar            | .. Mexico     | .. | Not introduced.   |
| 12. <i>Olyca phryganoides</i> Walker         | Haiti         | .. | Not introduced.   |
| 13, 14. <i>Olyca</i> spp.                    | .. California | .. | Adult moths not reared.   |
| 15. <i>Cactobrosis strigalis</i> B. and McD. | U.S.A.        | .. | Food-plant <i>Echinocereus</i> .  |
| 16. <i>Cactobrosis interstitialis</i> Dyar   | U.S.A.        | .. | Food-plant <i>Cylindropuntia</i> .  |
| 17. <i>Cactobrosis leuconips</i> Dyar        | Arizona       | .. | Food-plant <i>Echinocereus</i> .  |
| 18. <i>Cactobrosis fernaldialis</i> Hulst.   | Arizona       | .. | Food-plant <i>Ferocactus</i> .  |
| 19. <i>Tucumania porrecta</i> Dyar           | .. Uruguay    | .. | Not introduced.   |
| 20. <i>Tucumania tapiacola</i> Dyar          | Argentina     | .. | Not introduced.   |
| 21. <i>Yosemetia longipennella</i> Dyar      | Texas         | .. | Food-plant <i>Echinocactus</i> .  |
| 22. <i>Yosemetia graciella</i> Hulst.        | .. Arizona    | .. | Food-plant <i>Echinocereus</i> .  |
| 23. <i>Zophodia glaucatella</i> Hulst.       | Texas         | .. | Food-plant <i>Cylindropuntia</i> .  |
| 24. <i>Zophodia holochlora</i> Dyar          | .. Texas      | .. | Food-plant <i>Cylindropuntia</i> .  |
| 25. <i>Zophodia stigmaferella</i> Dyar       | Argentina     | .. | Not introduced.   |
| 26. Phycitid sp.                             | .. Venezuela  | .. | Adults not reared.  |
| 27, 28. Phycitid spp.                        | .. Brazil     | .. | Food-plant <i>Cereus</i> .  |
| 29. Phycitid sp.                             | .. Brazil     | .. | Adults not reared.  |

## PYRALIDÆ: Phycitinæ—continued.

- |                  |    |    |         |    |  |
|------------------|----|----|---------|----|--|
| 30. Phycitid sp. | .. | .. | Arizona | .. | Food-plant <i>Carnegiea gigantea</i> . |
| 31. Phycitid sp. | .. | .. | Peru    | .. | Food-plant <i>Cylindropuntia</i> .     |

## PYRALIDÆ: Pyraustinæ—

- |   |    |    |           |    |  |
|---|----|----|-----------|----|--|
| 32. <i>Mimorista flavidissimalis</i><br>Grote |    |    | U.S.A.    | .. | Liberated but did not become established; subsequently discarded as of minor importance. |
| 33. <i>Mimorista pulchellalis</i> Dyar        |    |    | Argentina | .. | Food-plant <i>Echinopsis</i> .   |
| 34. <i>Mimorista</i> sp.                      | .. | .. | Brazil    | .. | Not introduced.  |
| 35. <i>Laniifera cyclades</i> Druce           | .. | .. | Mexico    | .. | One introduction failed; still being investigated.                                       |

## GELECHIDÆ—

- |  |    |    |        |    |   |
|--|----|----|--------|----|---|
| 36. <i>Metapleura potosi</i> Busck.    | .. | .. | Mexico | .. | Discarded because tests not satisfactory. |
| 37. <i>Aerotypia pleurotella</i> Wals. |    |    | Mexico | .. | Not introduced.                           |

## TINEIDÆ—

- |                                       |    |    |        |    |                              |
|---------------------------------------|----|----|--------|----|------------------------------|
| 38. <i>Marmara opuntiiella</i> Busck. |    |    | U.S.A. | .. | Leaf miner of no importance. |
| 39. Leaf Miner                        | .. | .. | Peru   | .. | Adults not reared.           |

## LYCENIDÆ—

- |                                 |    |    |           |    |                   |
|---------------------------------|----|----|-----------|----|-------------------|
| 40. <i>Thecla melanis</i> Drury | .. | .. | Argentina | .. | Of no importance. |
|---------------------------------|----|----|-----------|----|-------------------|

## II.—Beetle Grubs that Attack the Stems and Joints.

## CERAMBYCIDÆ—

- |   |    |    |            |    |  |
|---|----|----|------------|----|--|
| 41. <i>Cenopæus palmeri</i> Le Conte        |    |    | U.S.A.     | .. | Food-plant <i>Cylindropuntia</i> .             |
| 42. <i>Moneilema ulkei</i> Horn             | .. | .. | Texas      | .. | Small numbers exist in cages and in the field. |
| 43. <i>Moneilema variolare</i> Thom.        |    |    | Mexico     | .. | Establishment under investigation.             |
| 44. <i>Moneilema crassa</i> Le Conte        |    |    | Texas      | .. | Establishment being attempted.                 |
| 45. <i>Moneilema gigas</i> Le Conte         |    |    | Arizona    | .. | Introduction failed.                           |
| 46. <i>Moneilema lævigata</i> Bland.        |    |    | New Mexico | .. | Introduction failed.                           |
| 47. <i>Moneilema corrugans</i> Casey        |    |    | New Mexico | .. | One introduction failed.                       |
| 48. <i>Moneilema rugosipennis</i><br>Fisher |    |    | Mexico     | .. | Introduction failed.                           |
| 49. <i>Moneilema appressa</i> Le Conte      |    |    | New Mexico | .. | Not introduced.                                |
| 50. <i>Moneilema nigriventris</i><br>Fisher |    |    | Texas      | .. | Not introduced.                                |
| 51. <i>Moneilema annulata</i> Say.          | .. | .. | Kansas     | .. | Not introduced.                                |
| 52. <i>Moneilema obtusa</i> Le Conte        |    |    | Utah       | .. | Not introduced.                                |
| 53. <i>Moneilema spoliata</i> Horn          | .. | .. | California | .. | Not introduced.                                |
| 54. <i>Moneilema armata</i> Le Conte        |    |    | Texas      | .. | Introductions failed.                          |
| 55. <i>Moneilema pollens</i> Casey          | .. | .. | Mexico     | .. | Not introduced.                                |
| 56. <i>Moneilema pimalis</i> Casey          | .. | .. | Mexico     | .. | Not introduced.                                |
| 57. <i>Moneilema mexicana</i> Fisher        |    |    | Mexico     | .. | Not introduced.                                |
| 58. <i>Moneilema opuntiae</i> Fisher        |    |    | Mexico     | .. | Not introduced.                                |
| 59. <i>Moneilema blapsides</i> Newm.        |    |    | Mexico     | .. | Not introduced.                                |
| 60. <i>Moneilema albopicta</i> White        |    |    | Mexico     | .. | Not introduced.                                |
| 61. <i>Moneilema punctipennis</i><br>Fisher |    |    | Mexico     | .. | Not introduced.                                |
| 62. <i>Moneilema ebenina</i> Bates          | .. | .. | Mexico     | .. | Not introduced.                                |

## CURCULIONIDÆ—

63. <i>Cactophagus spinolæ</i> Gyll.	Mexico	..	Discarded because tests not satisfactory.
64. <i>Cactophagus validus</i> Le Conte	Arizona	..	Not introduced.
65. <i>Cactophagus fahræi</i> Gyll.	.. Mexico	..	Not introduced.
66. <i>Cactophagus striatoforatus</i> Gyll.	Central America		Not introduced.
67. <i>Gerstæckeria doddi</i> Fisher	.. Texas	..	Tests not satisfactory.
68. <i>Gerstæckeria nobilis</i> Le Conte	Texas	..	Tests not satisfactory.
69. <i>Gerstæckeria porosa</i> Le Conte	U.S.A.	..	Tests not satisfactory.
70. <i>Gerstæckeria hubbardi</i> Le Conte	Florida	..	Not introduced.
71. <i>Gerstæckeria clathrata</i> Le Conte	Texas	..	Food-plant <i>Cylindropuntia</i> .
72. <i>Gerstæckeria cubæcola</i> Fisher	Cuba	..	Not introduced.
73. <i>Gerstæckeria insulana</i> Fisher	Haiti	..	Not introduced.
74. <i>Gerstæckeria</i> sp.	.. .. Mexico	..	Not introduced.
75. <i>Cactorama</i> sp.	.. .. Mexico	..	Not introduced.
76. <i>Cylindrocopturus</i> sp.	.. .. Mexico	..	Not introduced.
77. <i>Onychobaris mystica</i> Casey	Texas	..	Food-plant <i>Cylindropuntia</i> .
78. Curculionid sp.	.. .. Peru	..	Not introduced.

## CHRYSOMELIDÆ—

79. <i>Disonycha varicornis</i> Horn	Texas	..	Food-plant <i>Cylindropuntia</i> .
80. Chrysomelid sp.	.. .. Argentine	..	Adult not reared.

## III.—Flower, Fruit, and Seed Enemies.

## LEPIDOPTERA :

## PYRALIDÆ : PHYCITINÆ—

81. <i>Ozamia lucidalis</i> Walker	.. West Indies		Not introduced.
82. <i>Ozamia clarefacta</i> Dyar	.. Texas	..	Tests not satisfactory.
83. <i>Ozamia heliophila</i> Dyar	.. California	..	Not introduced.
84. <i>Ozamia thalassophila</i> Dyar	California	..	Not introduced.
85. <i>Ozamia hemilutella</i> Dyar	.. Argentine	..	Food-plant <i>Cereus</i> .
86. <i>Ozamia</i> sp.	.. .. Brazil	..	Adults not reared.
87. <i>Zophodia dilatifasciella</i> Rag.	Texas	..	Also attacks cochineal.
88. <i>Zophodia analamprella</i> Dyar	Argentine	..	Also attacks cochineal.
89. <i>Eurythmia hospitella</i> Zeller	Texas	..	Not introduced.
90. <i>Eurythmia anthophila</i> Dyar	Texas	..	Not introduced.
91. Phycitid sp.	.. .. Peru	..	Not introduced.
92. Phycitid sp.	.. .. Ecuador	..	Adult not reared.

## PYRALIDÆ : PYRAUSTINÆ—

93. <i>Noctuella elautalis</i> Grote	.. U.S.A.	..	Not introduced.
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## DIPTERA :

## CECIDOMYIDÆ—

94. <i>Asphondylia opuntiae</i> Felt.	U.S.A.	..	Tests being conducted.
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## HYMENOPTERA :

## CHALCIDIDÆ—

95. <i>Rileya</i> sp.	.. .. U.S.A.	..	Not introduced.
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## IV.—Plant-sucking Bugs (Hemiptera).

## CORIIDÆ—

96. <i>Chelinidea vittiger</i> Uhler	..	U.S.A.	..	Established in Australia.
97. <i>Chelinidea tabulata</i> Burm.	..	U.S.A.	..	Established in Australia.
98. <i>Chelinidea canyona</i> Hamlin	..	Texas	..	A small stock in cages.
99. <i>Chelinidea hunteri</i> Hamlin	..	Arizona	..	Food-plant <i>Cylindropuntia</i> .
100. <i>Chelinidea</i> sp.	.. ..	Venezuela	..	Not introduced.
101. <i>Narnia pallidicornis</i> Stal	..	U.S.A.	..	Introductions failed.
102. <i>Narnia snowi</i> Van Duzee	..	U.S.A.	..	Introductions failed.
103. <i>Narnia femorata</i> Stal	..	Central America	..	Not introduced.
104. <i>Narnia inornata</i> Dist.	..	Mexico	..	Not introduced.
105. <i>Leptoglossus fasciatus</i> Westw.	..	Argentina	..	Not introduced.
106. <i>Leptoglossus subauratus</i> Dist.	..	Central America	..	Not introduced.
107. <i>Leptoglossus concolor</i> Walker	..	Mexico	..	Not introduced.
108. <i>Leptoglossus</i> sp.	.. ..	Venezuela	..	Not introduced.

## CAPSIDÆ—

109. <i>Hesperolobops picta</i> Uhler	..	U.S.A.	..	Not introduced.
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## V.—Cochineal and Other Scale Insects (Homoptera).

## COCCIDÆ—

110. <i>Erium</i> sp.	.. ..	Argentina	..	Food-plant <i>Cereus</i> .
111. <i>Dactylopius tomentosus</i> Lam.	..	U.S.A.	..	Established in Australia.
112. <i>Dactylopius confusus</i> Kll.	..	America	..	Established in Australia.
113. <i>Dactylopius capensis</i> Green	..	South Africa	..	Established in Australia.
114. <i>Dactylopius coccus</i> Costa	..	America	..	A small stock in cages.
115. <i>Dactylopius indicus</i> Green	..	Argentina, Ceylon	..	Established in Australia.
116. <i>Dactylopius newsteadi</i> Kll.	..	U.S.A.	..	Established in Australia.
117. <i>Diaspis echinocacti</i> Bouche	..	America	..	Established in Australia.
118. Purple Scale	.. ..	Barbadoes	..	Not introduced.
119-121. Scale Insects	.. ..	Peru, Ecuador	..	Not introduced.

## VI.—Gall-forming Midges and Chalcids.

## DIPTERA :

## CECIDOMYIDÆ—

122. <i>Itonida opuntiae</i> Felt.	..	N. York Bot. Gardens	..	Not introduced.
123. <i>Neolasioptera</i> sp.	.. ..	Mexico	..	Not introduced.
124. <i>Phytophaga</i> sp.	.. ..	Texas	..	Not introduced.
125, 126. <i>Phytophaga</i> spp.	.. ..	Mexico	..	Not introduced.

## LONCHÆIDÆ—

127. <i>Lonchæa alexanderi</i> Brèthes	..	Argentina	..	Not introduced.
128. <i>Lonchæa</i> sp.	.. ..	Mexico	..	Not introduced.

## HYMENOPTERA :

## CHALCIDIDÆ—

129. <i>Callimome</i> sp.	.. ..	Mexico	..	Not introduced.
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## VII.—Miscellaneous Insects.

## LEPIDOPTERA :

## TINEIDÆ—

130. <i>Dyotopasta yumella</i> Kearfott	U.S.A.	..	Feeds within joints in association with <i>Melitara</i> caterpillars.
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## ARACHNIDA :

## ACARINA—

131. <i>Tetranychus opuntiae</i> Banks	Texas	..	Established in Australia.
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## VIII.—Scavenging Flies (Diptera).

## SYRPHIDÆ—

132. <i>Copestylum marginatum</i> Say.	U.S.A.	..	Introductions failed.
133. <i>Volucella esuriens</i> Fabr.	.. U.S.A.	..	Introductions failed.
134. <i>Volucella pusilla</i> Macq.	.. U.S.A.	..	Introductions failed.
135. <i>Volucella avida</i> O.S.	.. U.S.A.	..	Not introduced.
136. <i>Volucella fasciata</i> Macq.	.. U.S.A.	..	Introductions failed.
137. <i>Volucella fornax</i> Tns.	.. U.S.A.	..	Not introduced.
138. <i>Volucella satur</i> O.S.	.. U.S.A.	..	Not introduced.
139. <i>Temnocera spinigera</i> Wied.	Argentine	..	Not introduced.
140. <i>Temnocera scutellata</i> Mig.	.. Argentine	..	Not introduced.

## STRATIOMYIDÆ—

141. <i>Hermetia illucens</i> L.	.. U.S.A.	..	Introduction failed.
142. <i>Hermetia hunteri</i> Coq.	.. U.S.A.	..	Introduction failed.
143. <i>Hermetia chrysopila</i> Loew.	U.S.A.	..	Introduction failed.

## APPENDIX B.

## THE BOARD AND ITS STAFF.

## CHANGES IN THE PERSONNEL OF THE BOARD.

The original personnel of the Board comprised—

Mr. G. Lightfoot, Chief Officer of the Commonwealth Institute of Science and Industry;

Mr. W. Gordon Graham, Under Secretary, Department of Lands, Queensland;

Mr. G. Valder, Under Secretary, Department of Agriculture, New South Wales;

Professor T. Harvey Johnston, Scientific Controller, and associate member.

The Commonwealth representation was altered in May 1921, when Sir George Knibbs, Director of Institute of Science and Industry, succeeded Mr. Lightfoot; on the former's retirement in December 1925, Mr. Lightfoot again took his place on the Board.

The Queensland membership has undergone several changes. Mr. W. Gordon Graham was succeeded as Under Secretary of the Lands Department in November 1920 by Mr. G. L. Board, and the latter was succeeded by Mr. A. G. Melville in January 1922. In October 1926, Mr. Melville resigned his position on the Board in favour of Mr. F. D. Power, Deputy Chairman of the Prickly-pear Land Commission.

The New South Wales representation has been changed once, Mr. G. D. Ross replacing Mr. Valder in January 1926.

Professor E. J. Goddard, of the Queensland University, was co-opted as a fourth member of the Board in October 1926.

Mr. P. Murrell, of the Queensland Lands Department, has been Secretary and Accountant of the Board since its inception.

With the resignation of Professor Harvey Johnston in February 1923, the position of Scientific Controller with a seat on the Board was

abolished in favour of Officer in Charge of the scientific work. This position was held by Mr. J. C. Hamlin from February 1923 until his resignation in May 1924. Mr. Hamlin was succeeded by Mr. W. B. Alexander, who resigned from the Board's services in August 1925. The present Officer in Charge, Mr. Alan P. Dodd, was appointed in October 1925.

The present Membership and Staff of the Board is as follows:—

BOARD MEMBERS.

Mr. G. Lightfoot.  
Mr. F. D. Power.  
Mr. G. D. Ross.  
Dr. E. J. Goddard.

SECRETARY AND CLERICAL STAFF.

Mr. P. Murrell, Secretary and Accountant.  
Mr. E. Rowston, Assistant to the Secretary.  
Miss T. Bellingham, Stenographer, Sherwood Laboratory.

SCIENTIFIC STAFF.

*Officer in Charge of the Investigations.*  
Mr. Alan P. Dodd.

*Overseas.*

Mr. R. C. Mundell, Entomologist in charge.  
Mr. G. Barnette and Mr. M. G. Rodriguez, assistants.

*Central Laboratory, Sherwood.*

Mr. J. Mann, Research Entomologist.  
Mr. G. R. Bassingthwaite, Assistant in charge.  
Messrs. B. A. Smith and D. J. Porter, assistants.

*Gogango Field Station.*

Mr. F. H. Roberts, Research Entomologist and Officer in charge.  
Messrs. T. A. Cole, G. Youitt, H. Frazer, and S. H. Byron, assistants.

*Chinchilla Field Station.*

Mr. A. R. Taylor, Officer in charge.  
Messrs. V. Manuell and E. C. Blake, assistants.

*Gravesend Field Station.*

Mr. H. T. Nicholas, Officer in charge.  
Messrs. S. K. Bassingthwaite and R. P. Chadwick, assistants.

*Pathological.*

Mr. H. K. Lewcock, Pathologist.  
Mr. L. F. Mandelson, Assistant Pathologist.



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